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Damage Evolution in 3D Woven Composite Materials Using Acoustic Emission

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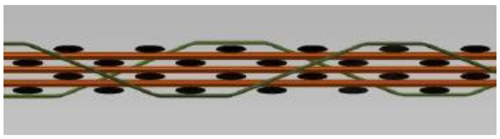
Fibre-reinforced composite materials are used extensively in the aerospace industry because of their high specific strength and stiffness, superior corrosion resistance and improved fatigue properties. In addition to the manufacturing costs and production rates, damage tolerance has become a major issue for the composite industry. Three-dimensional (3D) woven composites have superior through-thickness properties compared to two-dimensional (2D) laminate, for example, improved impact damage tolerance, high interlaminar fracture toughness and reduced notch sensitivity.

It is a big challenge to relate acoustic emission (AE) signal events to specific damage modes developed in composites under hygro-thermo-mechanical loading [1, 2]. This study provides further insight into the AE monitoring of a 3D angle interlock (AI) glass fibre composite materials (Figure 1) and has revealed the complex nature of the relationship between the principal characteristics of recorded AE events on the one hand and the complex damage mechanism on the other. This paper presents experimental and simulation results on the use of AE on 3D AI glass fibre composites for structural health monitoring (SHM) of transverse matrix cracks, and delamination during quasi-static tension of flat specimens. Tests were performed with piezoelectric sensors bonded on a tensile specimen acting as passive receivers of AE signals. A new set of experimental data has been generated which will be useful for validating numerical models, providing insight into the damage evolution of novel 3D AI glass fibre composites, and may ultimately lead to more effective material selection and determination of design limits.



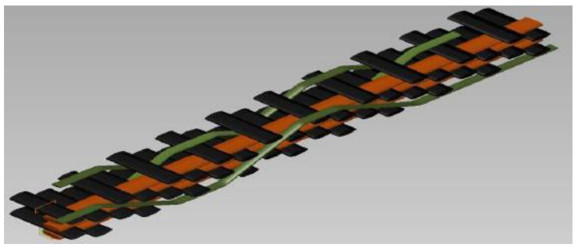


Figure 1. 3D Angle Interlock Woven Composite (front and perspective view) (orange: weft; black: warp; green: binder yarn) (Binder yarn goes all the way through-the-thickness and then returns back).

References:

1. M. Gresil, and V. Giurgiutiu, “Prediction of attenuated guided waves propagation in carbon fiber composites using Rayleigh damping,” in *Journal of Intelligent Material Systems and Structures,* September 8, 2014, DOI: 10.1177/1045389X14549870.
2. M. Gresil, M. Saleh, M. Arshad, and C. Soutis, “Acoustic emission of 3D angle interlock glass fibre composites,” in 10th International Workshop on SHM, Stanford USA, 2015.